

Earth, Wind, and Fire: Aeolian Activity in Burned Rangeland

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Introduction

On 6 December 1996, a grass fire blazed a path 10 km wide by 20 km long across open range between Sudan and Earth, Texas. The fire burned for two days, killed 50 cattle, injured one firefighter, and removed the protective grass cover from 20,000 hectares of rangeland. Grasses which had effectively anchored some of the sandiest soils on the Southern High Plains were now reduced to ashes and as the spring winds approached, the soil surface lay bare and ready to blow.

Wind and fire have always played an important role in the formation and evolution of the Southern High Plains. The geomorphic and sedimentological records of the Southern High Plains are dominated by aeolian processes (Holliday, 1995). The uppermost soils were deposited by wind (Reeves & Reeves, 1996) and then stabilized by grassland vegetation. Before farming divided the land and plowed much of the sod under, the Southern High Plains was a fairly continuous sea of grass (Webb, 1931) with few natural fire breaks. Fire could spread quickly across the plains leaving large areas of exposed soils (Pyne *et al.*, 1996). Although plains vegetation has evolved to survive such fires (Shantz & Zon, 1924; Brown, 1979), it takes time for the surface to recover fully.

In the case of the Sudan grass fire, the period of recovery would take months and would be marked by frequent aeolian activity. The area would provide a rare opportunity to study an actively eroding rangeland site as it evolved from a condition of maximum erodibility to a fully stable surface.

Methods

Two sampling locations were selected within the burned field. There was a considerable difference in the plant density between sites. Site 1 had a lower plant density than Site 2 and therefore had a noticeably higher fraction of exposed Brownfield loamy sand.

Aeolian activity was monitored by counting the number of particles that impacted a piezoelectric saltation sensor each second (Stockton & Gillette, 1990). A schematic drawing of the saltation sensor is shown in Fig. 1. Wind speed was simultaneously measured at a sampling rate of 1 Hz using a fast-responding cup anemometer mounted at a height of 2 m. In most cases, a one hour data set was collected at each of the two locations within the burned field.

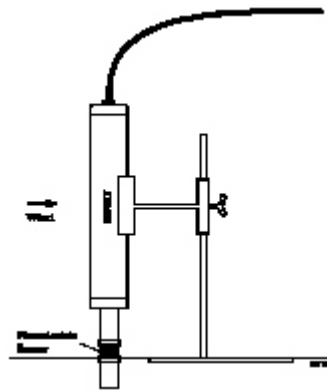


Figure 1. A piezoelectric saltation sensor.

Attempts were made to collect data whenever winds were sufficiently strong to cause significant sediment transport. Weather forecasts were monitored and when conditions appeared favorable we would travel the 90-km distance from Lubbock to the Sudan site to setup the experiment. Because we were dependent on natural winds and other weather factors, it was not possible to choose regularly spaced sampling dates. As a result the first three sampling dates were close together on March 18, March 24, and March 27. Due to excessive rain in April the last sampling date was on May 1 where we obtained measurements at Site 1 only. By June the entire field had become so stable that aeolian activity ceased. An example plot of the 2-m wind speed and saltation activity for Site 1 on March 27, 1997 is shown in Fig. 2.

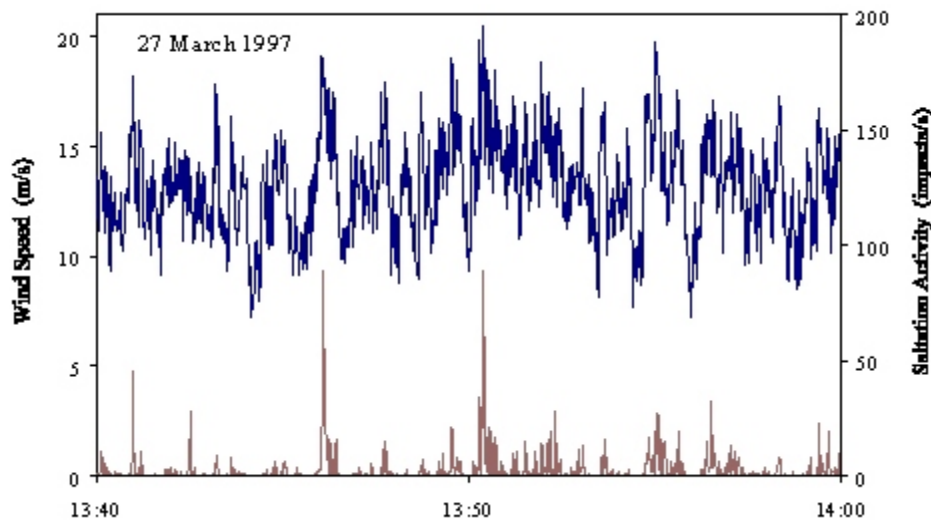


Figure 2. Wind speed and saltation activity measured at Site 1 on March 27, 1997.

Data Analysis

One measure of the susceptibility of a surface to wind erosion is its threshold wind speed – the wind speed at which sediment transport is initiated. High threshold values indicate a stable surface whereas low threshold values indicate a surface that is easily eroded by wind. Here we attempted to measure temporal changes in the threshold wind speed as the natural vegetation gradually recovered. Using each data set, separate threshold values were calculated using the “time fraction equivalence method” as discussed in Stout & Zobeck (1997) and Stout (1998). The guiding principle of this method is that the fraction of time that saltation activity is recorded by the saltation sensor should be equivalent to the fraction of time that winds exceed threshold. One simply has to determine by iteration the value of threshold that yields this equivalence.

The calculated threshold values are shown in Table 1. The results show that Site 1 had a much lower threshold than Site 2 indicating a significant difference in potential erodibility. In both cases there was a steady increase in threshold with time indicating surfaces that were moving toward stability as the vegetation recovered.

Table 1. Threshold wind speed u_t calculated from measured wind speed and saltation activity.

Date	u_t	u_t
	Site 1 (m/s)	Site 2 (m/s)
3/18/97	11.7	13.7
3/24/97	12.4	13.9
3/27/97	13.2	14.6
5/01/97	14.8	--

Photographs taken of the surface at Sites 1 and 2 indicate subtle changes in the vegetative cover as new blades of grass began to emerge from the burnt grass clumps. Surface cover was calculated from photographs taken on March 10, April 29 and July 10 using the photographic grid method (Laflen *et al.*, 1981). The results, shown in Table 2, indicate that between March 10 and April 29 there was a negligible change in surface cover which cannot explain the significant changes of threshold that were observed. Perhaps changes in the height of the plants were more significant in reducing the erodibility of the surface than changes in horizontal surface cover. Unfortunately, it was not possible to estimate effective plant height from the photographs since they were taken directly above each site.

Table 2. Fractional surface cover calculated from photographs.

Date	Fractional Surface Cover	
	Site 1	Site 2
3/10/97	0.38	0.47
4/29/97	0.40	0.48
7/16/97	0.69	0.73

Conclusions

The experimental methods employed here provide a technique for quantitatively documenting changes of erodibility in a burned and recovering rangeland setting. We have demonstrated that threshold can be used as an indicator of one aspect of erodibility – the stability of a surface subjected to wind forcing. The results show that it is possible to differentiate degrees of erodibility between two sites with different surface characteristics using threshold as a discriminating factor. The results also show that it is possible to follow temporal changes of erodibility as the vegetative cover of a surface slowly recovers by measuring temporal changes in threshold.

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